

WHEAT LEAF RUST

Wheat leaf rust, caused by the fungus *Puccinia triticina* (formerly *recondita* f. sp. *tritici*), reduces wheat yields in susceptible varieties when weather conditions favor rust development and spread. The most notable signs of leaf rust infection are the reddish-orange spore masses of the fungus breaking through the leaf surface (Figure 1). These spore masses, called pustules or uredinia, are first detected on wheat in North Dakota in late May or early June, generally in the southern-most counties. Normally, only a few pustules are visible on susceptible varieties in early June because spore numbers are still low. The disease develops prior to this period on susceptible winter or spring wheat crops grown in states farther south. The leaf rust spores are carried by wind currents, and the disease advances progressively northward across the Great Plains as the wheat crops develop (Figure 2). The leaf rust pathogen has only occasionally over-wintered in North Dakota, during a mild winter or when protected by deep snow.

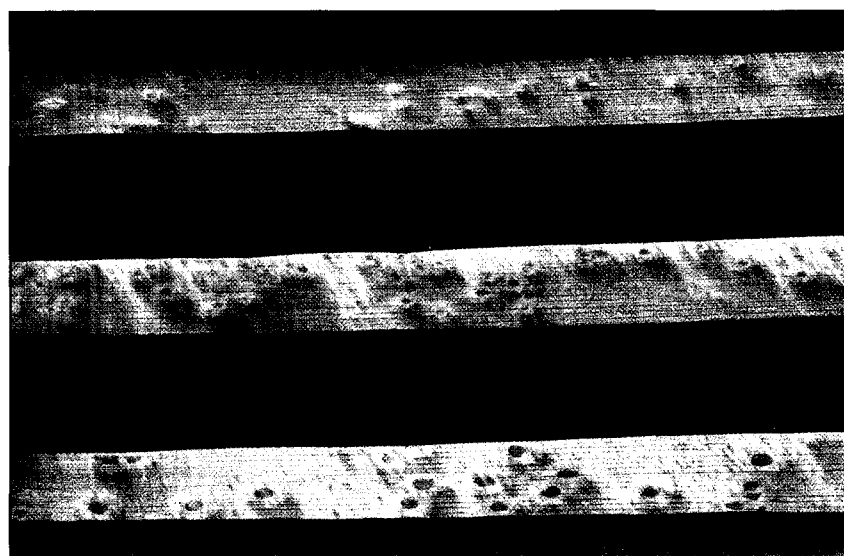


Figure 1. Top: Resistant reaction; Center: Moderately resistant reaction; Bottom: Susceptible reaction.

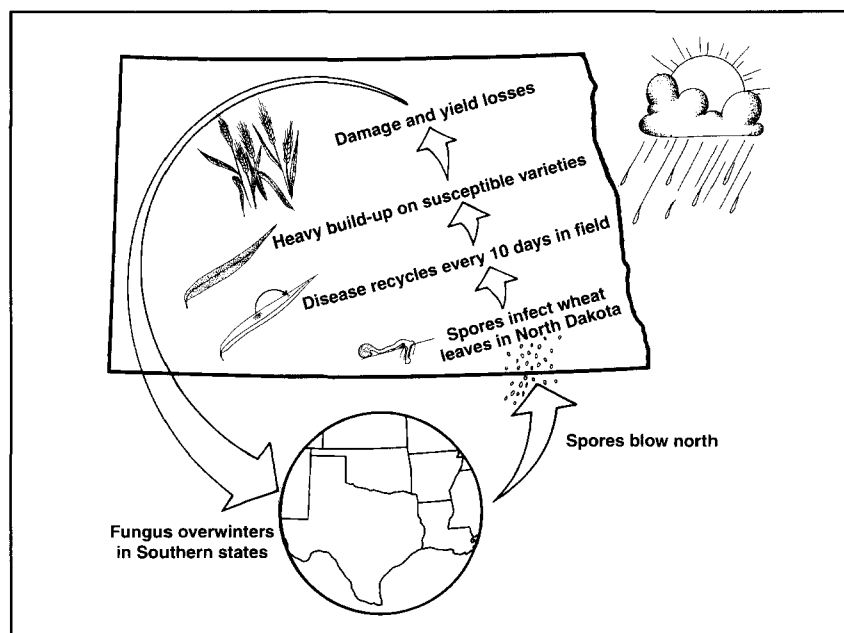


Figure 2. Leaf rust disease cycle.

44.3
19
8
0.
89
202



The Disease

The following factors must be present for wheat leaf rust infection to occur: viable spores; susceptible or moderately susceptible wheat plants; moisture on the leaves (six to eight hours of dew); and favorable temperatures (60 to 80 degrees Fahrenheit). Relatively cool nights combined with warm days are excellent conditions for disease development.

Under favorable environmental conditions, rust spores germinate and penetrate into the wheat leaf. The fungus obtains nutrients from the wheat leaf, and within a week to 10 days the fungus produces more spores, which erupt through the leaf surface. These newly produced spores are wind-blown to other wheat leaves or fields.

Resistant and susceptible wheats react differently to infection. If a variety is resistant, a reaction develops within the leaf which kills or retards the fungus, and the infection is stopped. Resistant varieties may develop yellowish-white "flecks" at the site of spore penetration (Figure 1). Moderately resistant varieties develop small reddish-orange pustules surrounded by a yellow-white halo (Figure 1). Susceptible varieties do not have the ability to retard fungal growth; the fungus grows extensively and produces relatively large pustules that may produce about 1,000 spores daily, each one of which is capable of reinfecting wheat (Figure 1). The outcome of a 10-day repeating cycle is the formation of many spores during the growing season, and these spores can move great distances on wind currents (Figure 2). Therefore, this disease can increase rapidly and epidemics may occur whenever susceptible varieties are grown and weather conditions are favorable for rust development.

The extent of yield losses caused by leaf rust depends on the severity and duration of infection. The greatest losses occur if the crop is severely rusted from the seedling stage to maturity. However, in North Dakota, this long duration of severe rust is unlikely, because leaf rust generally does not become severe until the crop reaches the boot stage (flag leaf fully developed) or later.

The amount of leaf area covered by leaf rust is expressed as percent severity (Figure 3) and can vary with weather, the amount of spores present, and the wheat variety. Yield losses are related to percent severity, especially on the top (flag) leaf. Wheat leaves manufacture carbohydrates and other nutrients. The flag leaf is a primary contributor to the nutrients necessary for grain fill. The greater the flag leaf area damaged by rust, the smaller the leaf area available to manufacture nutrients needed for producing plump kernels.

Initial infections are found on the lower leaves where high humidity persists for long durations. As the crop

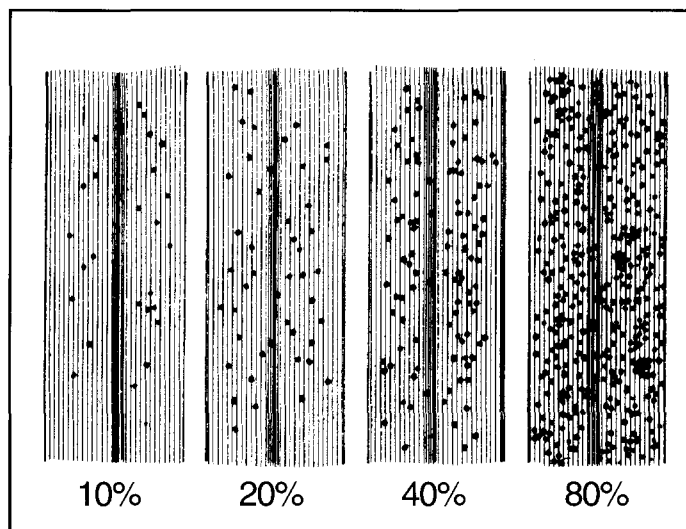


Figure 3. Percent severity.

develops and matures, leaf rust generally appears on upper leaves of plants and severity increases. Flag leaf severity on susceptible varieties may range from 40 to nearly 100 percent (Figure 3). In North Dakota, corresponding yield losses have been as high as 30 percent for severely infected susceptible varieties, **IF** severe infection occurred before flowering. If high leaf rust severity does not occur until the soft or hard dough stage, yield losses may range from 5 to 15 percent. Leaf rust also causes reduction of test weight, which can lower market grade and selling price.

Control

Resistance

Genetically inherited resistance is an excellent means of controlling leaf rust. Resistance limits infection and retards fungus growth and spore formation. Resistance levels vary among the classes of wheat and among varieties within a class. Varieties are classified according to the degree of resistance, R = Resistant, MR = Moderately Resistant, MS = Moderately Susceptible, and S = Susceptible. Susceptible varieties can suffer substantial yield loss (up to 30 percent in NDSU studies) when spores are present and environmental conditions are favorable. Varieties with MS reaction should be used with caution as damage may occur in favorable environments. Also, the natural leaf rust population is constantly

changing, as shifts in virulence or new races may occur. Varieties formerly considered resistant can become susceptible if new rust races develop.

Most of the hard red spring wheat cultivars grown in North Dakota through the first half of the 1990s were resistant to leaf rust. However, two factors have made the leaf rust situation less certain today. First, the threat of *Fusarium* head blight drove producers to plant large acreages of leaf rust-susceptible cultivars. Rust-susceptible cultivars can support the development of localized or wide-spread epidemics that can result in economic losses for producers in years when rust is heavy. Second, the natural population of the leaf rust fungus is genetically diverse and dynamic. The race composition of the pathogen population changed significantly in the second half of the 1990s. Races of the pathogen that were predominant in the population and essentially not problematic for producers in the early 1990s have been displaced by races that can affect popular cultivars. Consult NDSU Extension Circular A-574, North Dakota Hard Red Spring Wheat, Hard Red Winter Wheat Variety Performance Descriptions, for current rust resistance ratings of public and private varieties.

Most of the current winter wheat cultivars grown in North Dakota are susceptible to leaf rust and may require protection by fungicides. Two NDSU winter wheat releases, 'Elkhorn' and 'Jerry', have an MR reaction to current populations of leaf rust. A few winter wheat varieties developed for production in Nebraska and Kansas also have moderate resistance to leaf rust, but these varieties often are not winter hardy under our extreme winter conditions. Information about winter wheat variety responses to current races of leaf rust also is available in NDSU Extension Circular A-574. As with spring wheats, the development and prevalence of new races of leaf rust may make varieties previously considered to have MR reactions became susceptible.

Durum wheats have a "slow-rusting" reaction to leaf rust, and because of this, most durum varieties commonly grown in North Dakota are resistant to prevalent leaf rust races. Consult NDSU Extension Circular A-1067, North Dakota Durum Wheat Variety Performance Descriptions, for durum variety responses to leaf rust.

Fungicides

Fungicides available for wheat leaf rust control are used primarily to control infection on the flag leaf. Fungicides specifically registered (in 2002) for wheat leaf rust control are mancozeb (Dithane, Manzate, and Penncozeb), propiconazole (Tilt and Propimax), and

propiconazole + trifloxystrobin (Stratego) and azoxystrobin (Quadris). These fungicides also are registered for control of fungal leaf spots such as tan spot and Septoria, and mancozeb and propiconazole also have labels that allow heading application for *Fusarium* head blight (scab) control.

Fungicides are often re-evaluated for registered uses, and some new fungicides have good activity against leaf rust. Folicur (tebuconazole) has a Section 18 emergency exemption for use on wheat in 2002, but its registration status may change in subsequent years. With potential change in fungicide availability, it is important to consult the fungicide recommendations given in the **most current** NDSU Extension Circular PP-622, Field Crop Fungicide Guide.

Timing of application. Proper timing of fungicide application is important. Applications after the plants are fully headed and starting grain fill may be too late to provide adequate control. Also, if more than 5 percent of the flag leaf is covered with leaf rust it is probably too late to spray, because many spores may have already penetrated the leaf, producing infections that will not be visible for seven to 10 days.

Mancozeb fungicides are protectants; they establish a barrier between the germinating fungal spore and the leaf surface, but they cannot kill existing infections. To provide several weeks of protection, mancozeb is generally applied twice, the first application as soon as the flag leaf has fully emerged (early boot = Feekes 10), followed by a second application from seven to 10 days later. The full label rate of mancozeb is 2 lb/acre or 1.6 qt/acre, depending on formulation. The label instructions must be followed. Spreader-stickers are recommended for use with mancozeb to increase coverage and longevity.

Propiconazole (Tilt and Propimax) is a systemic fungicide and may provide some curative activity on very early infections. Propiconazole is generally applied once, at early flag leaf emergence (Feekes 8). A maximum of 4 fl. oz/acre of Tilt or Propimax is allowed per season. State 24c labels allow heading application of Tilt and Propimax up through full heading (Feekes 10.5).

Stratego also has a state label for application up through heading (Feekes 10.5) and Quadris's federal label allows application from immediately after jointing (Feekes 6) to late head emergence (Feekes 10.5). The Stratego labeled rate is 10 fl oz/acre and Quadris's labeled rate is 6.2-12.3 fl oz/acre.

Fungicides may be applied by ground or aerial application. Good coverage is essential for control; 15 to 20 gallons of water per acre is recommended for ground

application, while 5 gallons of water per acre is recommended for aerial application. For more information on aerial application, see NDSU Extension Circular PP-729, Aerial Application of Fungicides for Crop Disease Control.

Decision Guidelines for Fungicide Use. Wheat varieties resistant to leaf rust should be grown whenever possible. Most recommended winter wheat varieties are susceptible to leaf rust and should be monitored closely each year. Fungicides for leaf rust control are economically justified only if a susceptible variety is planted, a high yield potential exists, rust is present on leaves below the flag leaf, weather conditions favor rust development (warm days and cool nights with dew), and the price of wheat is adequate to provide economic return. The NDSU Disease Forecasting System (<http://www.ag.ndsu.nodak.edu/cropdisease/>) provides useful information on the likely occurrence of wheat leaf rust infections at numerous NDAWN weather stations across North Dakota.

Fungicide trials at NDSU showed that yield losses are highly correlated to rust severity and variety susceptibility. Fungicide applications to susceptible varieties have produced 10 to 20 percent yield increases in North Dakota, with greater return when rust was more severe. A worksheet can help estimate profit or loss from fungicide spray. With the assumption that a susceptible variety is grown, variables in the worksheet equation are: expected percent return from fungicide use; expected yield per acre; expected selling price of wheat; and price of fungicide application. All of these must be known or estimated before a decision to spray is made. An example based on a 20 percent yield return from fungicide use, a yield potential of 40 bushels per acre, wheat at \$3.00 per bushel, and 2002 fungicide costs of \$15/acre for one application of propiconazole, is presented on the worksheet.

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Worksheet for Determining Profitability of Fungicide for Wheat Leaf Rust Control

example

$$\begin{array}{rclclcl}
 \frac{20\%}{\text{Expected Yield Increase}} & \times & \frac{40 \text{ bu/A}}{\text{Expected Yield}} & \times & \frac{\$3.00}{\text{Expected Selling Price/bu}} & = & \frac{\$24.00}{\text{Expected Gross Return/A}} \\
 \\
 \frac{\$24.00}{\text{Expected Gross Return}} & - & \frac{\$15.00}{\text{Fungicide + Application Cost}} & = & \frac{\$9.00}{\text{Expected Net Return/A}}
 \end{array}$$

your field

$$\begin{array}{rclclcl}
 \frac{\%}{\text{Expected Yield Increase}} & \times & \frac{\text{bu/A}}{\text{Expected Yield}} & \times & \frac{\$}{\text{Expected Selling Price/bu}} & = & \frac{\$}{\text{Expected Gross Return/A}} \\
 \\
 \frac{\$}{\text{Expected Gross Return}} & - & \frac{\$}{\text{Fungicide + Application Cost}} & = & \frac{\$}{\text{Expected Net Return/A}}
 \end{array}$$

(worksheet adapted from one provided by Bob Bowden, Kansas State University Extension Plant Pathologist)



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